English Translation of Japanese Laid-Open Paten Application No. 2000-201134

[0023]

[Working-effect]

In the conventional multi-carrier system, as the information transmission speed increases and correlation of transmission line fluctuation between sub-carriers decreases, a large number of pilot symbols must be inserted for each sub-carrier but in the present invention, the pilot symbol inserting method is not restricted. Moreover, because in the present invention, all the inserted pilot symbols can be used for channel estimation and compensation of all the sub-carriers, channel estimation and compensation can be achieved with still higher accuracy and better efficiency.

[0024]

FIG. 1, FIG. 2, FIG. 3 show one example of the channel configuration according to the present invention that supports claim 1. Here, the abscissa of each channel is time and the ordinate is power. The information symbol is band-expanded by the high-speed diffusion code sequence and this band-expanded diffusion signal is transmitted by a plurality of sub-carriers SC1, …, SCM having frequency intervals n times (n: natural number) as many as the update frequency (chip rate) of the diffusion code sequence.

[0025]

To a plurality (M pieces) of sub-carriers SC1, .., SCM,

a plurality of communication channels SC11, …, SC1N1; …; SCM1, …, $SCMN_M$ are assigned, respectively. In each communication channel of each sub-carrier, a plurality of pilot symbols PL are time-multiplexedly inserted between information symbol IF sequences to carry out transmission.

[0026]

FIG. 1 indicates the channel configuration when the pilot symbol PL is inserted in all the transmission channels SC11, …, $SCMN_M$ at the same timing throughout all the sub-carriers SC1, …, SCM. FIG. 2 shows the channel configuration when the timing of each pilot symbol PL in each sub-carrier SC1, .., SCM differs. FIG. 3 shows the channel configuration when the pilot symbol PL is inserted in all the communication channels SC11, …, SC1N1; SCM1, …, $SCMN_M$ at the same timing in each sub-carrier SC1, …, SCM and when the pilot symbol PL timing varies in the sub-carriers.

[0027]

FIG. 5 shows one example of channel configuration according to the present invention which supports claim 2. Here, abscissa of each channel is time and ordinate power.

[0028]

The information symbol is band-expanded by the high-speed diffusion code sequence and this band-expanded diffusion signal is transmitted by a plurality of sub-carriers SC1, …, SCM having frequency intervals n times (n: natural number) as many as the update frequency (chip rate) of the diffusion code sequence.

[0029]

To a plurality (M pieces) of sub-carriers SC1, .., SCM, control channels common in each sub-carrier CCH1, …, CCHM and a plurality of communication channels SC11, …, SC1N1; …; SCM1, …, $SCMN_M$ are assigned, respectively. In communication channels common in each sub-carrier addressed to each sub-carrier, a plurality of pilot symbols PL are time-multiplexedly inserted between information symbol IF sequences to carry out transmission. In FIG. 5, there shown is the channel configuration when pilot symbol PL at common control channels in each sub-carrier CCH1, .., CCHM is inserted at the same timing throughout all the sub-carriers SC1, …, SCM, but the pilot symbol PL in common control channels in each sub-carrier CCH1, …, CCHM may be inserted at different timing for each sub-carrier.

[0030]

FIG. 6 shows one example of channel configuration of the present invention that supports claim 3. Here, abscissa of each channel is time and ordinate power.

[0031]

The information symbol is band-expanded by the high-speed diffusion code sequence and this band-expanded diffusion signal is transmitted by a plurality of sub-carriers SC1, …, SCM having frequency intervals n times (n: natural number) as many as the update frequency (chip rate) of the diffusion code sequence.

[0032]

Of a plurality (M pieces) of sub-carriers SC1, …, SCM, k pieces of control channel CCH common to all the sub-carriers

are assigned to k pieces (k: natural number, k<M) of sub-carriers. FIG. 6 shows the case of k=1, and the common control channel CCH is assigned to the sub-carrier SC1. In the common control channel CCH, a plurality of pilot symbols PL are time-multiplexedly inserted between information symbol IF sequences to carry out transmission.

[0033]

FIG. 7 shows one example of channel configuration according to the present invention which supports claim 4. Here, abscissa of each channel is time and ordinate power.

[0034]

The information symbol is band-expanded by the high-speed diffusion code sequence and this band-expanded diffusion signal is transmitted by a plurality of sub-carriers SC1, …, SCM having frequency intervals n times (n: natural number) as many as the update frequency (chip rate) of the diffusion code sequence.

[0035]

To a plurality (M pieces) of sub-carriers SC1, .., SCM, a plurality of communication channels CH11, …, $CH1N_1$; …; CHM1, …, $CHMN_M$ are assigned, respectively. In each communication channel, communication channels CHC11, …, $CHC1N_1$; …; CHCM1, …, $CHCMN_M$ for transmitting the information data and pilot channels CHP11, …, $CHP1N_1$; …; CHPM1, …, $CHPMN_M$ composed with pilot symbols are code-multiplexed and transmitted.

[0036]

FIG. 8 shows one example of channel configuration according to the present invention which supports claim 5. Here,

abscissa of each channel is time and ordinate power.

[0037]

The information symbol is band-expanded by the high-speed diffusion code sequence and this band-expanded diffusion signal is transmitted by a plurality of sub-carriers SC1, …, SCM having frequency intervals n times (n: natural number) as many as the update frequency (chip rate) of the diffusion code sequence.

[0038]

To a plurality (M pieces) of sub-carriers SC1, .., SCM, a plurality of communication channels CH11, …, $CH1N_1$; …; CHM1, …, $CHMN_M$ that store the information data IF and pilot channels common in sub-carrier CH1P, …, CHMP are assigned, respectively.

[0039]

FIG. 9 shows one example of channel configuration according to the present invention which supports claim 6. Here, abscissa of each channel is time and ordinate power.

[0040]

The information symbol is band-expanded by the high-speed diffusion code sequence and this band-expanded diffusion signal is transmitted by a plurality of sub-carriers SC1, …, SCM having frequency intervals n times (n: natural number) as many as the update frequency (chip rate) of the diffusion code sequence.

[0041]

To a plurality (M pieces) of sub-carriers SC1, .., SCM, a plurality of communication channels CH11, …, CH1N1; …; CHM1, …, $CHMN_M$ that transmit information data IF are assigned, respectively. k pieces of control channel CCH common to all

the sub-carriers are assigned to k pieces (k: natural number, k<M) of sub-carriers. FIG. 9 shows the case of k=1, and the common control channel CHP is assigned to the sub-carrier SC1. Of k pieces of sub-carrier, channels other than pilot channel CHP are assigned to the communication channels that transmit the information data.

[0042]

FIG. 10 and FIG. 11 show the multi-carrier/DS-CDMA demodulating apparatus according to the present invention that supports claim 7 and 8, respectively. FIG. 10 shows the demodulating apparatus when the channel configuration (see FIG. 1 through FIG. 3) as shown in claim 1 is used. FIG. 11 shows the demodulating apparatus when the channel configuration (see FIG. 7) as shown in claim 4.

[0043]

In FIG. 10, the received data sequence is decomposed into components for each sub-carrier SC1, …, SCM by the transformation means 1 such as FFT (fast Fourier transformation) or DFT (discrete Fourier transformation). Here, an example using FFT is introduced. The sequence for relevant each sub-carrier decomposed is supplied to reverse-diffusing means 31, …, 3M, where the sequence is reverse-diffused and taken out using the diffusion-code replica in conformity to the receiving timing of each multi-pass.

[0044]

When the pilot symbol is time-multiplexed to the information sequence as shown in FIG. 1 through FIG. 3, the

position of the pilot symbol contained in the sequence for each sub-carrier after reverse-diffusion is detected by the pilot detection section 5 and pilot symbols PL of M pieces of sequence are taken out. Using the pilot symbols PL detected, receiving channels at a plurality of pilot symbols PL contained in each sub-carrier SC1, …, SCM are averaged by the sub-carrier channel estimating sections 71, …, 7M, and the channel estimated value for each sub-carrier is found.

[0045]

The channel estimated value found for each sub-carrier is supplied to the sub-carrier synthesizing channel estimating section 9, and the sub-carrier is synthesized by averaging and linear-interpolating processing throughout the whole sub-carriers, and the channel estimated value of sub-carrier synthesis is found. Here, the averaged example is shown. The conjugate complex number of the channel estimated value and the data from reverse diffusing means 31, …, 3M are multiplied by the multipliers 111, …, 11M, respectively, to compensate for the fading phase variations of each information symbol. The signal after phase variation compensation is supplied to the parallel serial converter 13 and converted into the serial data. This serial data is supplied to the RAKE synthesizing section 15 together with the signal from other RAKE fingers and the common mode is synthesized.

[0046]

In FIG. 11, the receiving data sequence is decomposed into components for each sub-carrier SC1, …, SCM by the transforming

means such as FFT, DFT, etc. Here, a case using FFT is shown. The sequence for each sub-carrier decomposed is supplied to the reverse diffusing means 31P, 31C; …; 3MP, 3MC, where pilot channels CHP1x_1, …, CHPMx_M (where, x_1 is any one of 1 through N_1 and a natural number of x_1 N_1, x_M is any one of 1 through N_M and a natural number of x_M N_M) and communication channels CHC1x_1, …, CHCMx_M (where, x_1 is any one of 1 through N_1 and a natural number of x_1 N_1, x_M is any one of 1 through N_M and a natural number of x_M N_M) (hereinafter, x1 and xM are defined in the same manner) are reverse-diffused and taken out by the use of the diffusing code replica in accordance with the receiving timing of each multi-pass.

[0047]

The sequence of the pilot channel reverse-diffused is entered in channel estimating sections 71, …, 7M addressed to each sub-carrier, and the receiving channels at a plurality of pilot symbol PL contained in each sub-carriers SC1, …, SCM are averaged and the channel estimated value for each sub-carrier is found.

[0048]

The channel estimated value found for each sub-carrier is supplied to the sub-carrier synthesizing channel estimating section 9, and the sub-carrier is synthesized by averaging and linear-interpolating processing throughout the whole sub-carriers, and the channel estimated value of sub-carrier synthesis is found. Here, the averaged example is shown. The conjugate complex number of the channel estimated value and the

data from reverse diffusing means 31P, 31C;…; 3MP, 3MC are multiplied by the multipliers 111P, 111C; …; 11MP, 11MC, respectively, to compensate for the fading phase variations of each information symbol. The signal after phase variation compensation is supplied to the parallel serial converter 13 and converted into the serial data. This serial data is supplied to the RAKE synthesizing section 15 together with the signal from other RAKE fingers and the common mode is synthesized.

[0049]

FIG. 12 and FIG. 13 show the multi-carrier/DS-CDMA demodulating apparatus according to the present invention that supports claim 9 and 10, respectively. FIG. 12 shows the demodulating apparatus when the channel configuration (see FIG. 5) as shown in claim 2 is used. FIG. 13 shows the demodulating apparatus when the channel configuration (see FIG. 8) as shown in claim 5.

[0050]

In FIG. 12, the received data sequence is decomposed into components for each sub-carrier SC1, …, SCM by the transformation means such as FFT. Here, an example using FFT is introduced. The sequence for relevant each sub-carrier decomposed is supplied to reverse-diffusing means 31P, 31C; …, 3MP, 3MC, where common control channels CCH1, …, CCHM in sub-carriers contained in each sequence and the communication channels $CH1x_1$, …, $CHMx_M$ desired to demodulate are reverse-diffused and taken out using the diffusion-code replica in

conformity to the receiving timing of each multi-pass.

[0051]

The position of the pilot symbol contained in common control channels in sub-carrier CCH1, …, CCHM after reverse-diffusion is detected by the pilot detection section 5 and pilot symbols PL of M pieces of sequence are taken out. Using a plurality of pilot symbols PL detected, receiving channels at a plurality of pilot symbols PL contained in each sub-carrier SC1, …, SCM are averaged by the sub-carrier channel estimating sections 71, …, 7M, and the channel estimated value for each sub-carrier is found.

[0052]

The channel estimated value found for each sub-carrier is supplied to the sub-carrier synthesizing channel estimating section 9, and the sub-carrier is synthesized by averaging and linear-interpolating processing throughout the whole sub-carriers, and the channel estimated value of sub-carrier synthesis is found. Here, the averaged example is shown. The conjugate complex number of the channel estimated value and the data from reverse diffusing means 31P, 31C; …; 3MP, 3MC are multiplied by the multipliers 111P, 111C; …; 11MP, 11MC, respectively, to compensate for the fading phase variations of each information symbol. The signal after phase variation compensation is supplied to the parallel serial converter 13 and converted into the serial data. This serial data is supplied to the RAKE synthesizing section 15 together with the signal from other RAKE fingers and the common mode is

synthesized.

[0053]

In FIG. 13, the receiving data sequence is decomposed into components for each sub-carrier SC1, …, SCM by the transforming means such as FFT, DFT, etc. Here, a case using FFT is shown. The sequence for each sub-carrier decomposed is supplied to the reverse diffusing means 31P, 31C; …; 3MP, 3MC, where pilot channels contained in each sequence CH1P, …, CHMP and communication channels desired to demodulate $CH1x_1$, …, $CHMx_M$ are reverse-diffused and taken out by the use of the diffusing code replica in accordance with the receiving timing of each multi-pass. The sequence of the common pilot channel in sub-carrier CH1P, …, CHMP reverse-diffused is entered in channel estimating sections 71, …, 7M, respectively, and the receiving channels at a plurality of pilot symbol PL contained in each sub-carriers SC1, …, SCM are averaged and the channel estimated value for each sub-carrier is found. The channel estimated value found for each sub-carrier is supplied to the sub-carrier synthesizing channel estimating section 9, and the sub-carrier is synthesized by averaging and linear-interpolating processing throughout the whole sub-carriers, and the channel estimated value of sub-carrier synthesis is found. Here, the averaged example is shown. The conjugate complex number of the channel estimated value and the data from reverse diffusing means 31P, 31C;…; 3MP, 3MC are multiplied by the multipliers 111P, 111C; …; 11MP, 11MC, respectively, to compensate for the fading phase variations of each information

symbol. The signal after phase variation compensation is supplied to the parallel serial converter 13 and converted into the serial data. This serial data is supplied to the RAKE synthesizing section 15 together with the signal from other RAKE fingers and the common mode is synthesized.

[0054]

FIG. 14 and FIG. 15 show the multi-carrier/DS-CDMA demodulating apparatus according to the present invention that supports claim 11 and 12, respectively. FIG. 14 shows the demodulating apparatus when the channel configuration (see FIG. 6) as shown in claim 3 is used. FIG. 15 shows the demodulating apparatus when the channel configuration (see FIG. 9) as shown in claim 6.

[0055]

In FIG. 14, the received data sequence is decomposed into components for each sub-carrier SC1, …, SCM by the transformation means such as FFT. Of the sequence for each decomposed sub-carrier, k pieces (k=1 in FIG. 14) of control channel CCH common to all the sub-carriers and communication channels $CH1x_1$, …, $CHMx_M$ desired to demodulate in each sub-carrier are reverse-diffused and taken out using the diffusion-code replica in conformity to the receiving timing of each multi-pass. Here, the case of k=1 is shown. The pilot detecting section supplies k pieces of control channels CCH, detects the pilot symbol PL position contained in k pieces of control channels CCH common to all the sub-carriers after reverse diffusion and takes out the pilot symbol PL. A

plurality of pilot symbols PL detected are synthesized and supplied to the channel estimating section 7, and the channel estimated values are found for a plurality of pilot symbols. The conjugate complex number of the channel estimated value and the data CCH, CH11, …, $CH1N_1$; …; CHM1, …, $CHMN_M$ are multiplied by the multipliers 110, 111, 112, …; 11M, to compensate for the fading phase variations of each information symbol. The signal after phase variation compensation is supplied to the parallel serial converter 13 and converted into the serial data. This serial data is supplied to the RAKE synthesizing section 15 together with the signal from other RAKE fingers and the common mode is synthesized.

[0056]

In FIG. 15, the receiving data sequence is decomposed into components for each sub-carrier SC1, …, SCM by the transforming means such as FFT, DFT, etc. From the sequence of each decomposed sub-carrier, k pieces (k=1 in FIG. 15) of pilot channel CHP common to all the sub-carriers and communication channels desired to demodulate $CH1x_1$, …, $CHMx_M$ are reverse-diffused and taken out by the use of the diffusing code replica in accordance with the receiving timing of each multi-pass. Here, the case of k=1 is shown. The sequence of k pieces of the pilot channel common to all the sub-carriers is entered in the channel estimating section 7, where a plurality of pilot symbols are synthesized, and a channel estimated value is found for a plurality of pilot symbols. The conjugate complex number of the channel estimated value and the data CHP, $CH1x_1$, …, $CHMx_M$

are multiplied by the multipliers 110, 111, 112, …; 11M to compensate for the fading phase variations of each information symbol. The signal after phase variation compensation is supplied to the parallel serial converter 13 and converted into the serial data. This serial data is supplied to the RAKE synthesizing section 15 together with the signal from other RAKE fingers and the common mode is synthesized.

[0057]

[Mode for Carrying out the Invention]

Example 1

The working example 1 of multi-carrier/DS-CDMA channel estimation according to the present invention is shown in FIG. 16. FIG. 16 is a working example in which multi-carrier/DS-CDMA channel estimation that supports claim 7 is carried out. Here, averaging is carried out at the sub-carrier synthesis channel estimating section 9.

[0058]

The sequence of each sub-carrier SC1, …, SCM shown in FIG. 16 corresponds to the output obtained by reverse diffusion in FIG. 10. FIG. 16 shows the case when the pilot symbol PL of the Np symbol component contained in each sub carrier is contained in the same timing.

[0059]

The position of the pilot symbol PL which is contained as much as Np symbol is detected by the pilot detection section 5 at the same timing as the sequence after reverse diffusion for each sub-carrier and the pilot symbol PL for the Np symbol

is entered in each sub-carrier channel estimating sections 71, …, 7M. By each sub-carrier channel estimating sections 71, …, 7M, the receiving channel at Np symbol is averaged and the channel estimated value for each sub-carrier is found. The channel estimated values (M pieces) found for each sub-carrier are entered in the sub-carrier synthesizing channel estimating section 9, M pieces of channel estimated values are averaged over all the sub-carriers, and the channel estimated value of averaging sub-carriers is found. Using the channel estimated value found by averaging sub-carriers, as shown in FIG. 10, the fading phase variations of the information sequence for the Nd x M symbols are compensated for all the sub-carriers.

[0060]

Example 2

FIG. 17 shows Example 2 of the multi-carrier/DC-CDMA channel estimation according to the present invention. FIG. 17 is a working example that carries out multi-carrier/DS-CDMA channel estimation corresponding to claim 7 by the use of the channel configuration of claim 1. In this example, averaging is carried out at the sub-carrier synthesizing channel estimation section 9.

[0061]

The sequence of each sub-carrier SC1, …, SCM shown in FIG. 17 corresponds to the output obtained by carrying out reverse diffusion in FIG. 10. FIG. 17 shows the case in which the Np pilot symbol PL contained in each sub-carrier is contained at a different timing.

[0062]

In Example 2, since the pilot symbol position contained in each sub-carrier differs, the timing of pilot symbol PL contained as much as the Np symbol is detected, respectively, in the sequence after reverse diffusion for each sub-carrier by the pilot detection section 5 at the different timing. Using the timing detected, the pilot symbol PL for the Np symbol with respect to each sub-carrier is detected and entered in each sub-carrier channel estimating sections 71, …, 7M. By each sub-carrier channel estimating sections 71, …, 7M, the receiving channels at the Np symbol are averaged and the channel estimated value is found for each sub-carrier. The procedure thereafter is same as that of Example 1.

[0063]

Example 3

FIG. 18 shows Example 3 of multi-carrier/DS-CDMA channel estimation according to the present invention. FIG. 18 is a working example that carries out multi-carrier/DS-CDMA channel estimation corresponding to claim 8 by the use of the channel configuration of claim 4. In this example, averaging is carried out at the sub-carrier synthesizing channel estimation section 9.

[0064]

The sequence of each sub-carrier SC1, …, SCM shown in FIG. 18 corresponds to the output obtained by carrying out reverse diffusion in FIG. 11.

[0065]

The sequence after the reverse diffusion of pilot channel to each sub-carrier is entered in each sub-carrier estimating sections 71,…, 7M. At each sub-carrier channel estimating section 71, …, 7M, the receiving channels at the N symbol is averaged and the channel estimated value for each sub-carrier is found. The channel estimated values (M pieces) for each sub-carrier found are entered in the sub-carrier synthesizing channel estimation section 9, M pieces of channel estimated values are averaged throughout the whole sub-carriers, and the channel estimated value that averages whole sub-carriers is found. Using the channel estimated values found from averaging whole sub-carriers, as shown in FIG. 11, the fading phase variations of information sequence for the NxM symbol with respect to all the sub-carriers is compensated for.

[0066]

Example 4

FIG. 19 shows Example 4 of multi-carrier/DS-CDMA channel estimation according to the present invention. FIG. 19 is a working example that carries out multi-carrier/DS-CDMA channel estimation corresponding to claim 9 by the use of the channel configuration of claim 2. In this example, averaging is carried out at the sub-carrier synthesizing channel estimation section 9.

[0067]

The sequence of each sub-carrier SC1, …, SCM shown in FIG. 19 corresponds to the output obtained by carrying out reverse diffusion in FIG. 12.

[0068]

By the pilot detection section 5, the position of the pilot symbol PL for the Np symbol contained in the sequence after reverse diffusion of common control channels CCH1, …, CCHM in the sub-carrier is detected with respect to each sub-carrier. Using the timing detected, the pilot symbol PL for the Np symbol content is detected to each sub-carrier, and entered in each sub-carrier channel estimating section 71, …, 7M. The receiving channels at Np symbols are averaged by each sub-carrier channel estimating section 71, …, 7M and the channel estimated value for each sub-carrier is found. The channel estimated values (M pieces) found for each sub-carrier are entered in the sub-carrier synthesizing channel estimating section 9, M pieces of channel estimated values are averaged over all the sub-carriers, and the channel estimated value of averaging sub-carriers is found. Using the channel estimated value found by averaging sub-carriers, as shown in FIG. 12, the fading phase variations to the information sequence for the Nd symbols in the common control channels CCH1, …, CCHM in the sub-carrier and to the information sequence contained in the communication channel in each sub-carrier are compensated for all the sub-carriers.

[0069]

Example 5

FIG. 20 shows Example 5 of multi-carrier/DS-CDMA channel estimation according to the present invention. FIG. 20 is a working example that carries out multi-carrier/DS-CDMA channel

estimation corresponding to claim 10 by the use of the channel configuration of claim 5. In this example, averaging is carried out at the sub-carrier synthesizing channel estimation section 9.

[0070]

The sequence of each sub-carrier SC1, …, SCM shown in FIG. 20 corresponds to the output obtained by carrying out reverse diffusion in FIG. 13.

[0071]

By the sequence after reverse diffusing the common pilot channels CHIP, …, CHMP in the sub-carrier for each sub-carrier is entered in each sub-carrier channel estimating sections 71, …,7M. By each sub-carrier channel estimating section 71, …, 7M, the receiving channel at the N symbol contained in the common pilot channels CH1P, …, CHMP in the sub-carrier for each sub-carrier are averaged and the channel estimated value for each sub-carrier is found. The channel estimated values (M pieces) found for each sub-carrier are entered in the sub-carrier synthesizing channel estimating section 9, M pieces of channel estimated values are averaged over all the sub-carriers, and the channel estimated value of averaging sub-carriers is found. Using the channel estimated value found by averaging sub-carriers, as shown in FIG. 13, the fading phase variations of the information sequence contained in the communication channel of all the sub-carriers are compensated for.

[0072]

Example 6

FIG. 21 shows Example 6 of multi-carrier/DS-CDMA channel estimation according to the present invention. FIG. 21 is a working example that carries out multi-carrier/DS-CDMA channel estimation corresponding to claim 11 by the use of the channel configuration of claim 3. In this example, averaging is carried out at the sub-carrier synthesizing channel estimation section 9.

[0073]

The sequence of each sub-carrier SC1, ..., SCM shown in FIG. 21 corresponds to the output obtained by carrying out reverse diffusion in FIG. 14.

[0074]

By the pilot detection section 5, the position of the pilot symbol for the Np symbol contained in the sequence after reverse diffusing common control channels CCH for all the sub-carriers is detected. Using the timing detected, the pilot symbol PL for the Np symbol content is detected and entered in channel estimating section 7. The receiving channels at Np symbols are averaged by each sub-carrier channel estimating section 7 and the channel estimated value is found. Using the channel estimated value found, as shown in FIG. 14, the fading phase variations to the information sequence for the Nd symbols in the common control channels CCH for all the sub-carriers and to the information sequence contained in the communication channel of all the sub-carriers are compensated for.

[0075]

Example 7

FIG. 22 shows Example 7 of multi-carrier/DS-CDMA channel estimation according to the present invention. FIG. 22 is a working example that carries out multi-carrier/DS-CDMA channel estimation corresponding to claim 12 by the use of the channel configuration of claim 6. In this example, averaging is carried out at the sub-carrier synthesizing channel estimation section 9.

[0076]

The sequence of each sub-carrier SC1, …, SCM shown in FIG. 22 corresponds to the output obtained by carrying out reverse diffusion in FIG. 15.

[0077]

The sequence after reverse diffusing the common pilot channels CHP for all sub-carriers is entered in channel estimating sections 7. By the channel estimating section 7, the receiving channels at the pilot symbol contained in the common pilot channel for all the sub-carriers are averaged and the channel estimated value is found.

[0078]

Using the channel estimated value found, as shown in FIG. 15, the fading phase variations of the information sequence contained in the communication channel of all the sub-carriers are compensated for.

[0079]

[Effect of the Invention]

According to the present invention, in which the transmission path fluctuations in each sub-carrier is made

equal by averaging pilot symbols of all the sub-carriers, it is possible to estimate the fluctuations of the transmission path at increased accuracy and to estimate the multi-carrier/DS-CDMA channel that compensates for the fluctuations.

[0080]

In the conventional multi-carrier system, as the information transmission speed increased and the correlation of transmission fluctuations between sub-carriers decreases, a large number of pilot symbols must be inserted for each sub-carrier, whereas in the present invention, the pilot symbol inserting method is not restricted. Furthermore, because in the present invention, all the pilot symbols inserted can be used for channel estimation and compensation, it is possible to achieve still higher accuracy and higher efficiency estimation and compensation for the channel.

[Brief Description of the Drawings]

FIG. 1 is a channel configuration corresponding to claim 1;

FIG. 2 is a channel configuration corresponding to claim 1;

FIG. 3 is a channel configuration corresponding to claim 1;

FIG. 4 is a channel configuration explaining the conventional pilot symbol insertion;

FIG. 5 is a channel configuration corresponding to claim 2;

FIG. 6 is a channel configuration corresponding to claim

3;

FIG. 7 is a channel configuration corresponding to claim 4;

FIG. 8 is a channel configuration corresponding to claim 5;

FIG. 9 is a channel configuration corresponding to claim 6;

FIG. 10 is a block diagram showing one example of multi-carrier/DS-CDMA demodulating apparatus of the present invention corresponding to claim 7;

FIG. 11 is a block diagram showing one example of multi-carrier/DS-CDMA demodulating apparatus of the present invention corresponding to claim 8;

FIG. 12 is a block diagram showing one example of multi-carrier/DS-CDMA demodulating apparatus of the present invention corresponding to claim 9;

FIG. 13 is a block diagram showing one example of multi-carrier/DS-CDMA demodulating apparatus of the present invention corresponding to claim 10;

FIG. 14 is a block diagram showing one example of multi-carrier/DS-CDMA demodulating apparatus of the present invention corresponding to claim 11;

FIG. 15 is a block diagram showing one example of multi-carrier/DS-CDMA demodulating apparatus of the present invention corresponding to claim 12;

FIG. 16 is an explanatory drawing of working example 1 of multi-carrier/DS-CDMA channel estimation;

FIG. 17 is an explanatory drawing of working example 2 of multi-carrier/DS-CDMA channel estimation;

FIG. 18 is an explanatory drawing of working example 3 of multi-carrier/DS-CDMA channel estimation;

FIG. 19 is an explanatory drawing of working example 4 of multi-carrier/DS-CDMA channel estimation;

FIG. 20 is an explanatory drawing of working example 5 of multi-carrier/DS-CDMA channel estimation;

FIG. 21 is an explanatory drawing of working example 6 of multi-carrier/DS-CDMA channel estimation; and

FIG. 22 is an explanatory drawing of working example 7 of multi-carrier/DS-CDMA channel estimation.

DESCRIPTION OF REFERENCE NUMERALS

1 Conversion means

30, 31, …, 3M Reverse diffusion means

31P, 31C; …; 3MP, 3MC Reverse diffusion means

5 Pilot detection section

71, …, 7M Sub-carrier channel estimation section

9 Sub-carrier synthesizing channel estimation section

111, …, 11M Multiplier

111P, 111C; …; 11MP, 11MC Multiplier

13 Parallel serial converter

15 RAKE synthesizing section

FIG. 1, FIG. 2, FIG. 3, ...FIG. 6

IF

INFORMATION

FIG. 7, FIG. 8, FIG. 9

IF

PILOT

FIG. 10

RECEIVED DATA SERIES

1 FFT

31 REVERSE DIFFUSION

5 PILOT DETECTION SECTION

71 SUB-CARRIER CHANNEL ESTIMATING SECTION

CHANNEL ESTIMATED VALUE FOR EACH SUB-CARRIER

9 SUB-CARRIER SYNTHESIZING CHANNEL ESTIMATING SECTION

CHANNEL ESTIMATED VALUE OF SUB-CARRIER SYNTHESIS

SIGNAL FROM OTHER RAKE FINGER

15 RAKE SYNTHESIS SECTION

FIG. 11, FIG. 12, FIG. 13, FIG. 14, FIG. 15

ONE OF CHP11, ... CHP1N

FIG. 21, FIG. 22

SIGNAL AFTER REVERSE DIFFUSION

NA SYMBOL

PILOT

CHANNEL ESTIMATED VALUE

CONTROL CHANNEL COMMON TO ALL SUB-CARRIERS

ANY ONE OF COMMUNICATION CHANNELS CH21, ..., CH2N2

CHANNEL ESTIMATED VALUES COMMON TO ALL SUB-CARRIERS

FIG. 16, FIG. 17, FIG. 18

AVERAGE OF M PIECES OF CHANNEL ESTIMATED VALUES

AVERAGE CHANNEL ESTIMATED VALUES OF ALL SUB-CARRIERS

FIG. 19, FIG. 20

COMMON CONTROL CHANNEL IN SUB-CARRIER

ANY ONE CH1X1 IN COMMUNICATION CHANNELS CH11, ..., CH1N1